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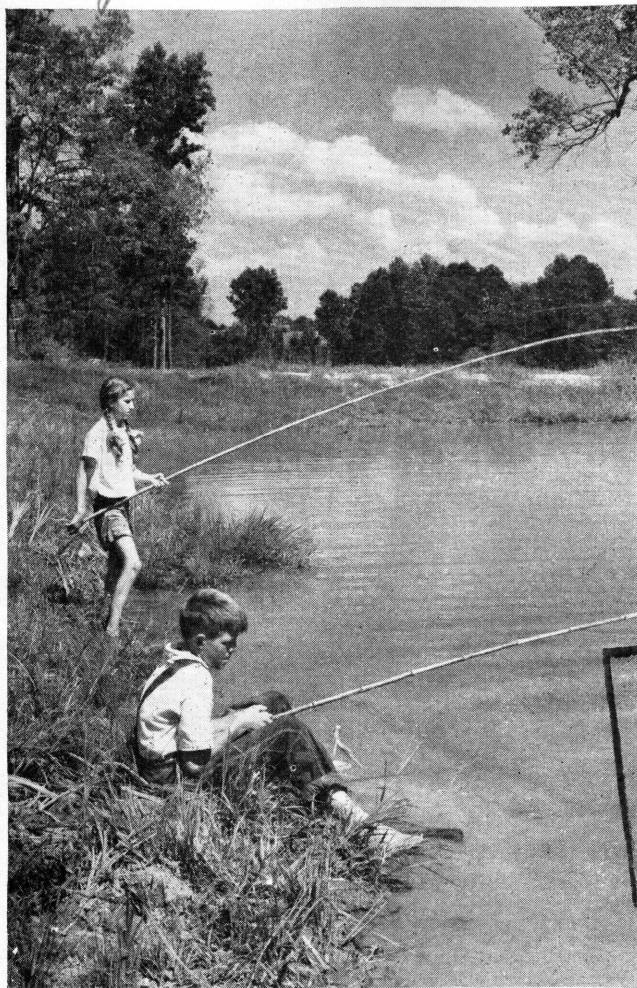
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**FARMERS'  
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**U. S. DEPARTMENT OF AGRICULTURE**

# **FISH FOR FOOD** **from farm ponds**

**U. S. DEPARTMENT OF AGRICULTURE**

**M**AKING the best use of every acre is the foundation of a sound farm conservation program. Where a suitable site for a farm fishpond exists, no better use can be made of such land than to develop it for the production of an ample supply of fish for the farm family. This is especially true in war-time, when home production of food is more important than ever, and a well-balanced diet is essential to meet the unusual demands of total war.

Fresh fish taken at any time from a readily accessible farm pond can form an important part of the country diet. Thousands of farms have suitable fishpond sites which, if properly developed and managed by farmers, would provide both pleasure and profitable returns to more than a million farm people.

This bulletin explains how fishponds can be constructed with the equipment and materials ordinarily available on farms and how such ponds can be managed to encourage rapid production of an ample supply of fish for farm use. The information will be useful to individual farmers and to those groups that have formed soil conservation districts for a united attack on soil and water conservation problems. Although the management methods discussed are based on experience in the Southeast, the same principles, with slight changes in specifications required by local conditions, are applicable in many other parts of the country.

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# FISH FOR FOOD FROM FARM PONDS

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## INTRODUCTION

Fish as food and fishing as an occupation have had tremendous influence on human lives throughout the ages. From the coastal areas of the United States alone more than 3 billion pounds of marine fish are ordinarily harvested every year. These are consumed as fresh fish within 200 miles of the coast and in the larger cities and towns. Elsewhere they are available as frozen, canned, salted, pickled, dried, and smoked fish. In spite of the large quantities of fish taken from coastal waters, the average farmer seldom has fresh fish on his table and is not likely to unless he produces them on his own place. By way of contrast, farmers in France for centuries have eaten fish produced on flooded grainfields as part of regular crop rotations.

Many farms have suitable sites for the construction of ponds. These sites, properly developed and managed for fish, will contribute substantially to better living on the farm, since a single acre of pond can be made to yield 150 to 450 pounds of pan-size fish annually. Farmers in the Southeast alone could profitably produce some 60 million pounds of fish each year at a cost of only a few cents a pound. Foods from field crops or livestock are produced no more economically.

Fresh fish in farm diets would not only help to promote proper development of growing children, thereby contributing to the strength and soundness of the Nation's rural youth, but also improve the health and capacity for work of adults. The annual consumption of meats, including red meats, fish, and fowl, in the United States averages 163 pounds per person. Of this total, only 15.3 pounds consists of fish. Something like 163 pounds of meat is needed to maintain health and vigor. In the Southeast, however, most farm people eat less than 154 pounds of meat, and this consists principally of pork and poultry. One acre of fertilized pond (see p. 6) will produce two or three times as much meat as the average person consumes. Fish, of course, should not replace all other meats but can be used to supplement them, adding pleasant variety and many essential food elements to the diet. Fish is a good source of proteins and fats. It is high in phosphorus and contains substantial amount of calcium and iron. Niacin and vitamins A, B, and C also are present.





FIGURE 1.—Fishing in their own pond gives a measure of satisfaction to the farm family.

Under the stress of war production and during the period of economic and mental readjustment in returning to peace, as well as in normal times, families on the land need recreation. Recreation afforded by a good fishpond is hard to surpass (fig. 1).

### MANAGEMENT OF FISHPONDS

Fishpond management involves intelligent care and use of water and fish within a pond. For satisfactory management a pond must have adequate depth, contain the right kinds of fish, be free of pond weeds, and have the watershed protected by soil conservation measures.

The Alabama Agricultural Experiment Station in conducting experiments in fishpond management discovered a number of management principles that formerly were not recognized and understood.<sup>1</sup> As a result of this and subsequent developments, gratifying results are being obtained in raising fish as a farm crop. These relatively new measures are, fortunately, simple and successful.

The objective of fishpond management is to produce and harvest fish of usable size totaling the greatest number of pounds, rather than to produce innumerable small fish or a few extremely large ones. The capacity of a pond to provide food for fish is stated in the number of pounds of fish per acre that it will support. The total weight of

<sup>1</sup> SWINGLE, H. S., and SMITH, E. V. MANAGEMENT OF FARM FISH PONDS. Ala. Agr. Expt. Sta. Bul. 254, 23 pp., illus. 1942.

The assistance of the authors of this publication in making available experimental data and reviewing the present bulletin is appreciatively acknowledged.

fish is governed by the fertility of the pond water which, in a natural condition, is largely dependent upon the fertility of its watershed. Application of commercial fertilizers in suitable amounts makes it possible for Alabama ponds to maintain 400 to 600 pounds of fish per acre where, otherwise, the same ponds support as little as 40 and no more than 200 pounds. A pond supporting 400 to 600 pounds per acre should contain 300 to 450 pounds of fish of usable size, or roughly 75 percent, while the remaining 25 percent of weight is divided among hundreds of smaller fish. All fish of usable size can be harvested at one time by draining the pond, but only approximately 50 percent of them can be caught annually even by ardent fishing with hook and line. Thus, a pond, well managed, will yield an average of 150 to 225 pounds per acre by hook-and-line fishing; or by draining the pond 300 to 450 pounds of fish large enough for table use can be harvested, together with the remaining 100 to 150 pounds of fish that are too small for any use except in restocking.

While thousands of farms have at least one good site for a fishpond, there are many others on which a suitable site cannot be found. A pond cannot be managed efficiently for high production of fish if a large watershed drains through it or if it becomes muddy with soil washing from eroding areas every time it rains. A pond containing nothing but shallow water or a high percentage of water less than 2 or 3 feet deep is hardly worth managing for fish production.

The size of a pond has considerable influence on whether or not it should be managed intensively. Owners cannot afford to fertilize lakes of many acres unless enough people will use the increased production of fish. Approximately 1,000 pounds of fertilizer is usually required annually for each surface acre of water, but ponds that receive water from more fertile land may require as little as 500 pounds per acre every year. A pond of only one-fourth acre or less is probably too small to justify management, although the yield will be proportionate to the size, and small ponds can be managed by following the principles outlined for larger ones.

A common fault of ordinary ponds is that they contain too many fish and therefore too few of usable size. Fish grow rapidly when sufficient food is available; but the supply of food is limited in every pond. The number of fish must be restricted accordingly if good fishing is to result. Every fisherman can recall ponds which contained thousands of fish little larger than minnows. No matter how often the fisherman returned year after year, fish were as numerous as ever but no larger. When fish are too plentiful, they get only enough food to remain alive but not enough to grow rapidly. They may never reach usable size, as even moderate overpopulation tends to retard growth. Yet, in southeastern ponds that are properly stocked and managed, fish attain pan size in a single year, and a favorable ratio in weight between pan-size fishes and smaller fishes can be maintained indefinitely.

To avoid having too many undersize fish, it is necessary to stock the pond with the right kinds of fish and to start them off in proper numbers. A pond containing only one kind of fish will not provide successful fishing. Large-mouth black bass (*Huro salmoides*) and bream, such as the bluegill (*Lepomis macrochirus*), have proved to be an excellent combination. Bass, which feed largely on fish, provide a

check against overpopulation in farm ponds just as they have always done in the wild. Bass eat a high percentage of their own young, but they do not grow satisfactorily without additional food, which is best provided by bream. This principle applies to every fishpond regardless of how small it may be. Proper numbers to use are given in the section on stocking.

Microscopic plants called algae, of which there are many kinds, grow and multiply in ponds where sunlight and temperatures are favorable. When sufficient nitrates, phosphates, potash, and other essential materials are present, these minute plants grow very rapidly and provide food for insects and water animals that are in turn eaten by fish. It takes considerable food to grow a pound of fish—or a pound of cotton, or beef, or pork for that matter. Bream feed largely upon aquatic insects that live within the pond itself rather than on those insects that fall into the water or are caught while flying close to the surface. Contrary to common belief, pondfishes are not dependent on waterweeds for food.

Waterweeds of every kind are undesirable in the best fishponds, for they interfere with fishing and are entirely unnecessary as food or cover for fish. Waterweeds are controlled in deep water by the use of fertilizer, as the increased algal growth robs the waterweeds of needed sunlight. Weeds in shallow water may be kept out with surprising ease by hand.

The following sections explain in detail how to apply these principles in managing fishponds. They also emphasize the importance of selecting suitable sites, building good dams and spillways, and protecting ponds from destructive forces of flood and erosion, thereby insuring a lasting pond that may be fished many times a year.

Ponds that are managed as recommended in this bulletin are also suitable for swimming and watering livestock and may be used in connection with the irrigation of small gardens where the flow of water is sufficient to replenish the pond in a short time.

### THE INITIAL STOCK OF FISH

The initial stock of fish, both the kind and the number, greatly influences the success of a fishpond. A successful pond should provide good fishing within a year after it is stocked and with proper care will continue to do so year after year.

Bream, such as the bluegill, and large-mouth black bass are recommended for farm ponds because this combination is the simplest to manage and will yield the most pounds of usable fish. Some land-owners like to include catfish, crappie, and other kinds, but experience has shown that mixing these species with bream and bass seldom improves the fishing.

With plenty of food, bream weighing 4 ounces and bass averaging 1 pound can be produced in 1 year. Approximately 1,500 bream and 100 large-mouth bass per surface acre of water are recommended for stocking new ponds that are to be properly fertilized. These two species remain in satisfactory balance as to size and numbers if the pond is so stocked, without further artificial introduction of fish.

Stocking rates for unfertilized ponds can only be estimated, as the productivity of natural waters varies with the fertility of the watershed. As explained earlier, natural fertility may be so low that an



acre pond will support 40 pounds or less, while other ponds can maintain 100 or 200 pounds of fish per acre. Since the number of fish to be stocked is dependent on the food supply that must be divided between them, a stocking rate of 400 bream and 25 or 30 bass should be followed for ponds that will support about 150 pounds of fish per acre. Fertilized ponds, on the other hand, are brought to a higher and more uniform level of fertility and will provide adequate food for approximately 1,500 bream and 100 bass.

**If too many fish are stocked there will not be sufficient food for each to reach pan size (fig. 2).**

Understocking with bass also results in poor fishing, surprising as it may seem, due to an overpopulation of bream before the end of the first spawning season. This latter condition occurs because the bass are not able to reduce the bream sufficiently. As a result a large number of early hatched bream grow rapidly, until the carrying capacity of the pond is reached—then their growth stops. These half-grown young bream are large enough to spawn, too large to be taken easily by the young bass, but not large enough for the frying pan. Bass fail to reproduce because

the thousands of starved bream eat the bass eggs. The old bass seldom bite because of the unlimited supply of small bream on which to feed. It is, therefore, evident that partial stocking is a mistake and that a few adults should never be placed in a pond ahead of or instead of complete stocking.

The initial stock of fish for a new pond may be obtained from Federal hatcheries, or, in some cases, from State hatcheries. Farmers cooperating with soil conservation districts may obtain fish for stocking through their district organizations. Applications should indicate definitely the exact size of the pond and the number of bream



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FIGURE 2.—The large bream obtained sufficient food to reach pan size within a year, but the small ones failed to grow because they were crowded in a pond where there were too many fish for the amount of food available.

and bass desired; also whether or not the pond will be fertilized and what kind of fish, if any, are already present. The size of the pond should be figured to the nearest tenth of an acre and stocked proportionately.

Bream are usually delivered by the hatcheries in the fall (August to December). Early stocking is very desirable in the Southeast, as bream grow rapidly during the fall months, and results in larger adult fish at spawning time the next June. Both bream and bass fingerlings may be stocked at the same time, in which case they should be of about equal size when placed in the pond. Bass fingerlings are not always available in the fall, but in that case bass fry (or small fingerlings) 3 to 5 weeks old, can be added the following spring. This delayed stocking of bass is satisfactory except that fishing must be limited to bream until the bass have spawned the next year. Bass should not be placed in a pond before the bream. It is equally important that the stocking of bass should not be delayed beyond May or June of the first year following the stocking of bream.

### FERTILIZING

The application of fertilizer accomplishes three outstanding things in pond management: First, it vastly increases the food for fish; second, it controls submerged pond weeds; and third, it makes fishing more successful, as fish bite more readily where the fisherman cannot be seen through the clouded water. For these reasons pond owners are strongly encouraged to include fertilization in their plans. A pond that becomes muddy with every rain cannot be fertilized successfully, however.

Commercial fertilizers will build up the food supply so that each acre of a pond will support from 400 to 600 pounds of fish. As previously explained, the increase of food in a fertilized pond is derived directly and indirectly from a tremendous growth of plants so small that they can be seen only with the aid of a magnifying glass. They are present in such numbers as to cloud the water with a green or brown tinge, depending on the kind of plant life.

Soils on watersheds above ponds are very frequently deficient in some plant-food elements. Pond waters, therefore, more or less lack nitrogen, phosphorus, potassium, and lime, depending on the condition of the surrounding lands. To compensate for these deficiencies in the water, the Alabama Agricultural Experiment Station recommends an application of 100 pounds of 6-8-4 mixed fertilizer (NPK), plus an additional 10 pounds of nitrate of soda for each surface acre of water. This application should be repeated at intervals, from spring until fall. For those who wish to mix their own fertilizer the Alabama station recommends the following formula for an acre of pond:

- 40 pounds of sulfate of ammonia
- 60 pounds of superphosphate (16-percent).
- 5 pounds of muriate of potash.
- 15 pounds of ground limestone.

As fertilization during the winter months yields only minimum returns, the first application should be made as soon as the water warms up in the spring. In various sections of the Southeast this will range from March to May. Two or three applications are made at weekly intervals in a new pond and, thereafter, only when plant growth in the

water becomes reduced to such a degree that the bottom can be seen where the pond is 12 to 18 inches deep. Applications are not made later than October or November, when cool weather reduces fish growth because of lower temperature. A person applies fertilizer to small ponds by walking around the edge and broadcasting the material toward the center by hand. It is not necessary to cover the entire surface, as wave action will distribute the food elements.

Most ponds will require 800 to 1,000 pounds of fertilizer per surface acre annually. Satisfactory results will not be obtained by the use of insufficient amounts of fertilizer. While 100 pounds of 6-8-4 plus 10 pounds of nitrate of soda is roughly equivalent to 100 pounds of an 8-8-4 fertilizer, other mixtures may prove with experience to be better for ponds in certain soil types. Where an 8-8-4, or a 6-8-4 fertilizer with addition of nitrate of soda, cannot be obtained, something close to these can be used with reasonable satisfaction.

Cottonseed meal, hay, manure and other organic materials have not been found satisfactory in the Southeast for fishpond fertilization. Tests, so far, have indicated that these organic fertilizers tend to produce objectionable amounts of filamentous algae which interfere with fishing.

#### WEED CONTROL

**Leafy aquatic plants are undesirable in managed fishponds.** This includes all kinds of water weeds, such as cattails and waterlilies, which emerge above the surface, and "mosses" and similar submerged plants that usually fill clear-water ponds. Water weeds should be kept out because they foster the breeding of malaria-carrying mosquitoes; hinder bass from preventing an overpopulation of bream; utilize the fertilizer placed in a pond without greatly increasing food for fish; and interfere, as fishermen well know, with fishing.

The vast increase of algae, resulting from applications of fertilizer, colors the water and, by cutting off sunlight, keeps underwater weeds from becoming established. Fertilizer, however, does not prevent emergent plants such as pond lilies, cattails, and parrot feather from rooting in shallow water. These types of weeds must be controlled by hand. For this reason a pond should be deepened at the edges, as explained on page 17. Water weeds appear first at the edge, which makes it necessary to inspect shallow areas frequently and remove volunteering plants. This is not difficult if individual plants are pulled before they produce seed or spread into colonies. An ordinary shovel may be used for this purpose. When left undisturbed, shallow-water plants soon become heavily rooted and more difficult to eradicate.

Where pond lilies and similar plants with heavy root stalks are already established, the roots can be starved by cutting the leaves frequently just below the surface. It may require cutting during two summers to exhaust the plant food that is stored in the roots. Where submerged water weeds are already established, fertilization should be started in December or January. This treatment brings on a heavy growth of filamentous algae that kills the water weeds by a smothering shade.

Weeds and brush must also be controlled on the banks of the pond. A strip at least 15 feet wide should be cleared next to the water's edge and should be grazed or mowed so that its low herbaceous cover will be maintained (fig. 3).





R2-300

FIGURE 3.—A cleared strip around the pond improves fishing, reduces the breeding places of mosquitoes, and keeps the pond free of undesirable debris.

### FISHING

When ponds are stocked with the correct kinds and numbers of fish and fertilizer is added regularly each year, heavy fishing is possible and desirable. The original stocking of fish reaches the total carrying capacity of a pond the first year. Little further growth is possible until fishing removes a portion of the fish, leaving an increased food supply for those remaining. Good management, therefore, includes a definite effort to remove as many pan-size fish as convenient, so that young fish may obtain plenty of food to bring them, in turn, to usable size. Failure to do this results in a waste of fish and fertilizer. This is one reason that it is so important to have a pond of the right size. One that is too large for the farm needs is either wasteful or proves a burden. Good management includes removing from a 1-acre fertilized pond, by hook and line, the equivalent of 25 to 50 1-pound bass and 500 to 700  $\frac{1}{4}$ -pound bream, a total of from 150 to 225 pounds of fish each year. This will provide food at the rate of 3 or 4 pounds of live fish per week. The average person consumes about a pound of beef each week; so farm ponds are capable of adding materially to the family diet, not only in the quantity of food, but also in valuable food elements.

H. S. Swingle and E. V. Smith, of the Alabama Agricultural Experiment Station, have found by fishing fertilized ponds that—

When the number of fish in the pond is reduced, the food for those remaining increases, and as the food per individual increases, the fish bite less often. During this period of poorer fishing, the fish grow rapidly; as the maximum weight which the pond can support is approached, they bite more and more readily,

and fishing once again becomes "good." Alternating periods of good and poor fishing are therefore to be expected in all ponds which are adequately fished.

### **DRAINING THE POND**

There are three possible reasons for wanting to drain a fishpond: (1) A mistake may have been made in stocking or some unexpected mishap may upset the balance between fish and their foods; (2) repair or reconstruction may become desirable; and (3) the owner may wish to harvest all the pan-size fish at one time. A good drain pipe is invaluable under any one of these conditions.

The quickest and safest cure for errors in stocking is to drain the pond and restock it correctly. Although it is not anticipated that a mishap will upset the balance in a pond, fish have been known to die from unexplained causes. Most misfortunes can easily be corrected if the pond was provided with a drain when the dam was built.

Fertilized waters support a standing crop of something like 300 to 450 pounds of fish per acre. Landowners sometimes wish to harvest the maximum number of fish produced. They may want to share fish with neighbors and friends at a community fish fry or harvest large quantities for some other purpose. In such cases draining is the most satisfactory means of obtaining all the pan-size fish. As noted before, however, only about 50 percent of the usable fish can be caught annually by hook and line.

Drainage is not a difficult job. The reservoir is allowed to drain to about one-fourth of its capacity. Then careful attention must be given as the remaining water drains from the pond. The fish are collected below the dam when they come through the pipe. Collecting fish and sorting them is greatly facilitated by using a fish trough that can be simply constructed with hardware cloth on a wooden frame. The open end is fitted over the drain opening below the dam.

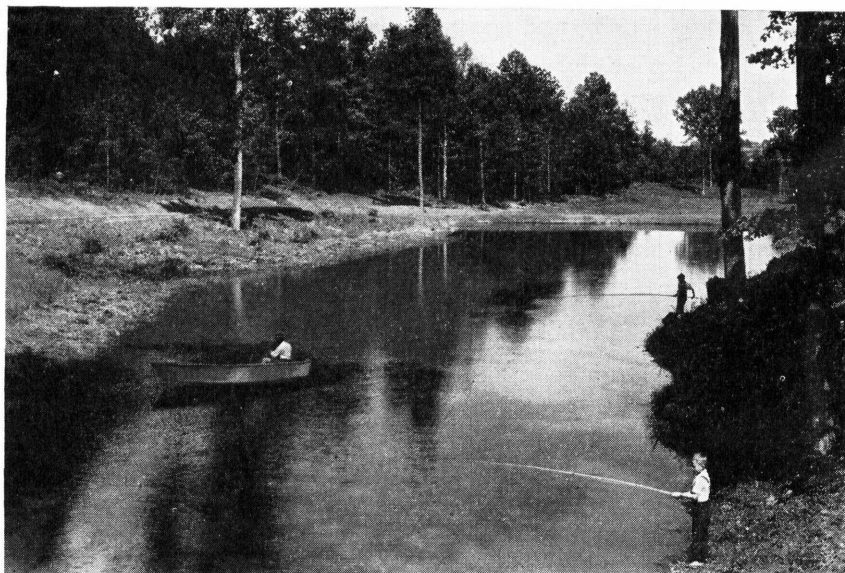
### **HOW TO BUILD A GOOD POND**

There are many farms on which suitable pond sites cannot be found. It is a mistake to build a pond on a poor site. The following sections discuss the important features in choosing a location for a manageable fishpond. They also explain principles of construction that are essential for a lasting pond to insure adequate fishing for the builder and his family.

It should be kept in mind that as many as 50 pounds of bass and 175 pounds of bream are likely to be caught annually from each acre of a well-fertilized pond. This is sufficient for an average family. These figures are based on an estimate that about half the legal-size fish can be caught by hook and line. A pond to be used by several families would, of course, have to be proportionately larger than an acre. Unless the owner allows friends to fish in his pond or wishes to sell fishing rights to others, it is best to hold rather close to a standard of 1 acre for each farm family.

In the interest of malaria control most State health departments in the South require a permit before pond construction is begun. These permits require nothing that will interfere with good pond management, and no charge is made for the permit or for inspecting the pond.





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FIGURE 4.—A pond provides good use of land on a well-chosen site.

### CHOOSING A LOCATION

Features that make a site suitable for fish management are briefly: (1) A small watershed from which relatively little runoff water and silt will enter the pond; (2) a basin in which to impound water without a large area of shallow water; and (3) a suitable supply of water. Sites to be avoided are: (a) Streams carrying considerable amounts of flood water; (b) shallow basins where depth would be insufficient; (c) steeply sloping valley floors that would require high dams; (d) ponds so large that their production of fish is more than the owner can use; and (e) those that would receive muddy water.

The most desirable sites occur in small valleys with steep sides and gradually sloping floors (fig. 4). Deep water at the edge resulting from fairly steep valley sides makes it easy to control emergent water plants, and a gently sloping valley floor makes it possible to impound a sizeable area of water with a dam of moderate height. Such sites are frequently wet and are better used as wildlife land than for cultivated crops or pasture. Even on small areas suitable for pasture or woods, a fishpond often provides better use of the land, particularly when the completed pond will provide water for livestock, too.

A suitable location for the dam and spillway will influence the size of a good pond. A dam should not be raised at the sacrifice of a good spillway location just to increase the size of a pond. Two or more ponds make an excellent arrangement for stocking and harvesting fish. Two small dams are often built at less cost than a large one to provide an equal area of water.

As a fairly uniform water level is desirable, particular attention should be paid to the source of water. The supply may come from springs, flowing wells, or streams; or from the runoff of terraced fields, pasture, or wooded areas. The runoff must be sufficient to re-

plenish waters lost by evaporation and seepage; and to keep it free from silt, soil conservation measures must be applied.

Perhaps the most common fault in locating a pond is selecting a site which normally has too much running water and carries still greater amounts during heavy rains. Such ponds cannot be built or managed economically for fish. Excessive quantities of water require masonry spillways, which are not discussed in this bulletin. Too much water washes fertilized waters out of the pond, dilutes the remainder with unfertile water, and usually carries silt into the pond and fish out of it.

A pond without a live water supply will require a sufficient watershed to furnish runoff water to fill the pond and replenish the water that is lost by evaporation and seepage. Exact acreages cannot be given as there is considerable variation in runoff from different soils and various slopes. Roughly, 10 to 12 acres of pasture and cropland or 30 acres of woodland will yield sufficient runoff water to maintain a pond of 1 acre in the Eastern States. In areas of the West, where the rainfall is light, larger acreages are required.

Where small streams, wells, or springs provide the water supply, a pond depth of 6 feet may be sufficient, although 8 feet of water would be better. On the other hand, where the only supply is runoff from terraced fields or from woodland or pastures a depth of 8 feet or more must be planned for the pond, since the water level will fall in dry seasons.

The best pond site on a farm is sometimes without water but within reach of a small stream that can be diverted into the basin. Some type of control gate will have to be used at the head of a diversion ditch where it leaves the stream, to prevent floodwaters or muddy water from damaging the ditch and the pond. Screens should be placed at the control gate to exclude undesired fish.

An ideal pond site, then, should be selected to insure:

1. A good reservoir in which to impound water.
2. A water supply as uniform as possible.
3. A depth of at least 6 feet where the water level remains constant; and a depth of 8 feet or more where the water fluctuates 1 foot or more.
4. A moderately small watershed, to avoid flood problems and one that is protected, so as to keep runoff waters free of silt.

### CLEARING THE SITE

Where it appears that a satisfactory quantity of water can be impounded by constructing a dam at a suitable point, the builder will need to stake the proposed water line with the aid of a level.

All trees, shrubs, and bushes should be cut from the area that will be covered with water. An additional strip 15 feet or more back from the water's edge should also be cleared of brush and trees as these are undesirable at the edge of managed ponds. (See fig. 3.)

Every tree and stump in the dam site should be removed. It is not necessary to dig or burn low stumps from the pond area or from the cleared borders around the edge, but all the logs, branches, and other debris should be burned or otherwise removed.

Leaves, dead branches, and other refuse clog the spillway, harbor mosquitoes, and destroy the neat appearance that should be maintained. Contrary to popular opinion, logs, stumps, or brush are not needed to aid spawning or to protect young bass and bream.

## INSTALLING OVERFLOW AND DRAIN PIPES

An overflow pipe, connected with the drain pipe by an elbow or T-branch, is a very satisfactory means of fixing the normal water level and helping protect spillways from failure. Vegetated spillways are most economical for farm ponds; but they sometimes fail, because of constant saturation of the spillway. By cutting the stand-pipe off 4 to 6 inches below the level of the flood spillway, all of the normal flow and much of the runoff water is carried through the drain pipe, thus permitting safer use of these inexpensive spillways.

Cast-iron or galvanized wrought-iron pipes are commonly used for drains; cast iron is the more expensive but lasts longer than wrought iron. A product known as asbestos-cement pipe appears to be satisfactory for drains, since it lasts well and costs somewhat less than metal pipe of equal size. Vitrified-clay sewer pipe is most economical, lasts almost indefinitely, and appears to be satisfactory when laid carefully on a firm foundation.

Pipe 6 or 8 inches in diameter makes a serviceable drain for ponds of an acre or two. Larger pipe is needed for larger ponds, particularly where considerable water is to be bypassed through the drain. Pipe 2 to 4 inches in diameter will drain small ponds if the incoming flow is negligible, but these small sizes are not recommended as they drain ponds very slowly and tend to become clogged.

**The drain must be placed so as to insure complete drainage of the pond.** If the installed pipe leaves undrained pockets, most of the fish will collect there and become imbedded in mud. The best drain is placed so that every bit of water and all the fish are brought through the pipe. Fish can be collected more easily below the dam than above it. Pipe should not be laid above the bottom elevation in anticipation of siltation, as no accurate estimate of siltation can be made and silt should be negligible in a good pond. Moreover, the rate of silt deposit is least at the deep end. Syphoning is not a satisfactory means of removing water and fish from a pond, and is more expensive than a permanent drain.

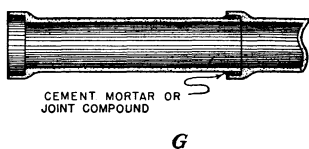
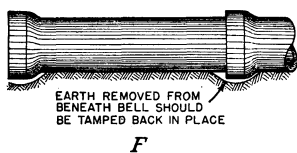
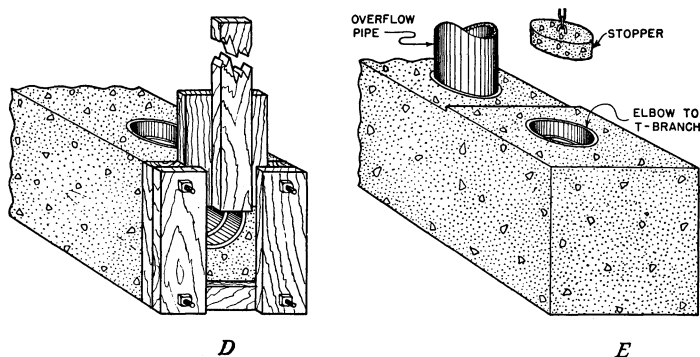
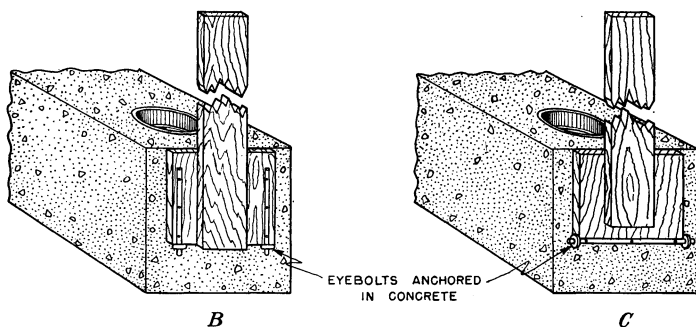
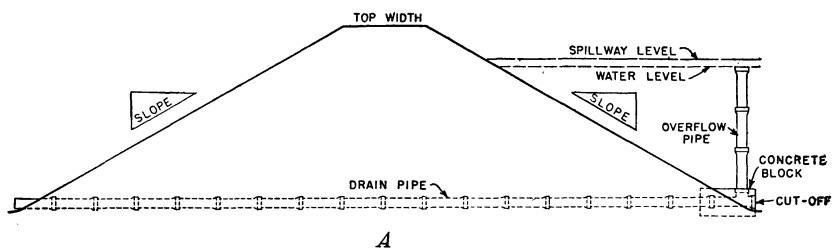
As explained earlier, vitrified clay sewer pipe of 6- or 8-inch size is a very good choice of material for a drain pipe, provided it is carefully installed. Figure 5 shows how this kind of pipe should be placed beneath a dam to obtain satisfactory results and shows various types of cut-offs that may be used at the opening to the drain.

Important principles of laying vitrified-clay sewer pipe are:

1. Lay the pipe on firm ground, preferably the clay subsoil. A place will be found across the dam site where subsoil lies at the exact elevation wanted for pipe installation, as shown in figure 6. A shovel, post-hole digger, or soil auger can be used to locate the right place to dig a trench for the pipe.

2. The trench should be at least 1 foot deep, and may be 2 or 3. The pipe should be laid in a straight line. The barrel of every joint must be firmly supported along its whole length except at the end, where a notch should be cut in the ditch to allow room for the bell end of each joint. If the weight of earth in the dam were allowed to rest mainly on the bell joints, some sections would settle out of line and breakage would result.

3. Joints should be filled with either a mortar of 2 parts sand and 1 part portland cement, or plastic-asphalt cement containing asbestos



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**FIGURE 5.**—Installation of drain pipe, overflow pipe, and cut-offs. A, The relation to dam and spillway when installed. B, C, D, and E, Various designs for cut-offs. F and G, Details of laying vitrified-clay sewer pipe.

fibers, or a hot-poured bituminous jointing compound sold commercially for this purpose. A sack, attached to a small rope, can be drawn through each section after the joint has been cemented to leave a smooth surface inside.

4. Clay should be tamped carefully around the pipe after all joints have been filled. The trench should then be filled before machinery is run over it. Thus, breakage is prevented and a watertight seal is made around the pipe.

5. A concrete block, if cast about the T-branch as shown in figure 5, will support the overflow pipe, protect the bell end against breakage, and anchor any kind of gate that is chosen for the cut-off.

6. An overflow pipe may be of vitrified clay, corrugated metal, cast iron, wrought iron, asbestos-cement, or it may be a brick chimney.

Asbestos-cement or cast-iron pipes can be used for the drain in much the same manner as sewer pipe is used. A vitrified-clay T-branch can be joined satisfactorily with any kind of pipe since it will be cast in a cement block which covers the union. If threaded iron or steel pipe is used, an elbow at the forward end is all that is needed to connect the overflow pipe to the drain.

Whatever the material used, the level of the overflow pipe should always be lower than the flood spillway, and the drain pipe should be low enough to permit every bit of water to drain freely from the pond when the cut-off is opened. As a general rule, the upper end of the overflow pipe should be 4 to 6 inches lower than the flood spillway. For flood-control purposes, a greater difference is advisable.

If a small auxiliary pond for holding fish is built, it also should be provided with a drain pipe.

### BUILDING THE DAM

**A common fault in constructing earthen dams is that the base is not made wide enough to allow for adequate slopes and top width.** The height and size of a dam will depend on the location of the flood spillway, the top width of the dam, and the slope of its sides. The following specifications are necessarily general but illustrate principles of safety and economy for dams up to 12 feet high. For design of the dam and spillway<sup>2</sup> of higher dams and those to be constructed on watersheds of more than 50 acres, an experienced engineer should be consulted.

A dam with a wide base and gentle slopes is much stronger than one with a narrow base and steep sides, as seepage of water through the dam is decreased and the chances of caving and slipping when saturated with water are reduced. A good top width protects a dam against failure by wave action, crayfish, muskrats and other burrowing rodents, and reduces the need for repairing damage from these causes. A dam with the same degree of slope on both sides and sufficient working width on top is easiest to build.

As a general recommendation for low dams that will be built of good soil material, 2-to-1 slopes on both sides are economical and reasonably safe. A top width of 7 feet is practical where teams will be used in construction; but where tractor equipment, such as bulldozer, rotary

<sup>2</sup> For further information see: HAMILTON, C. L., and JEPSON, H. G., STOCK-WATER DEVELOPMENTS: WELLS, SPRINGS, AND PONDS. U. S. Dept. of Agr. Farmers' Bul. 1859. 77 pp., illus. 1940. Also National Resources Committee. LOW DAMS. A MANUAL OF DESIGN FOR SMALL WATER STORAGE PROJECTS. 431 pp., illus. Washington, 1938.

scraper, and carrier, is used, a top width of approximately 10 feet is required. The base width of a dam having 2-to-1 slopes is equal to the top width plus four times the height of the dam at a given point. The length of pipe to be laid for a drain can be figured in this way.

Every pond site does not have good soil material available for dam construction. Where less favorable dam material is encountered, the slope on the pond side should be increased to 3 to 1. These extra-broad bases are needed also for dams of above moderate height and dams that impound several acres of water, as their failure may endanger life and property below. Undercutting these specifications for constructing earthen dams is false economy and will result in need for frequent repair, if not in complete failure of the structure.

A dam must have sufficient height above the normal water level to prevent water from overtopping the dam and washing it out during sudden or heavy rains. A height of at least 2 feet above the water level is recommended for dams up to 12 feet in height on watersheds of no more than 50 acres.

A good foundation for the dam should be prepared before piling loose earth on the site. This is accomplished by removing all stumps, roots, vegetation, and trash and then scooping the topsoil to the lower toe of the dam. This scooped-off area should then be broken with a turning plow to insure a good "seal" between the old earth surface and the new fill.

A clay-core wall is usually needed to cut off seepage through the porous soils which have been deposited by nature in the bottom of draws across which dams generally are constructed. Such a core is made by digging the washed-in material from a trench 4 to 10 feet wide down to a watertight soil (usually clay subsoil) and refilling with a good clay soil. The trench should extend the full length of the dam at its center line. If the body of the dam is to be built of less favorable soil material, the core wall should be carried on up inside the dam to water-level height, but when soils for the dam contain good clay, the core wall need only be brought to the top of the core trench to join with the fill. Clay should be tamped thoroughly in layers 4 to 6 inches thick, as it is placed in the core. **A core wall beneath the dam is desirable even where a constant flow of water will maintain a stable water level, but this cutoff wall is absolutely necessary to avoid loss of water by seepage from ponds that are fed by runoff water alone.**

The tools at hand will largely determine the way to move the soil. Teams and drag pans are commonly used and produce a well-packed dam. Bulldozers, rotary scrapers, drag pans powered by tractors, steam shovels or trucks are faster and are particularly suitable for larger construction jobs.

An additional foot of soil must be put on the top of each 10 feet of dam height to allow for settling. Settling is sometimes greater at one point than at others, and more soil will be needed to even up the top so that the dam will have no low places in it. It is desirable to construct the fill in uniform layers of earth 4 to 6 inches deep, keeping each layer as nearly level as practicable and completing one before starting the next. Moist soil makes a well-compacted fill.

A pond can be improved substantially and the dam can be built at less cost if the soil for the fill is taken from carefully selected areas

within the pond and from the flood spillway (fig. 6). Soil removed from above the water level leaves an exposed subsoil that is ugly and difficult to revegetate. Digging the spillway is a necessary exception, of course. The best clay and the shortest hauls are usually obtained near the dam from one or both sides of the basin. Around the pond,

the water level should be marked and soil taken from that line downward leaving a steeply sloping edge. Not even the slightest pocket should be left, however, at a lower elevation than the drain pipe.

As soon as possible after the dam is completed it should be sprigged with Bermuda grass or seeded with a standard pasture mixture or other adapted vegetation to protect the fill from erosion and wave action.

### THE FLOOD SPILLWAY

A good spillway is just as important as a good dam. The spillway problem is two-fold: First, a spillway must be wide enough to carry floodwater out of the pond without danger to the dam; and, second, water must be lowered to the bottom of a stabilized draw without creating an overfall which

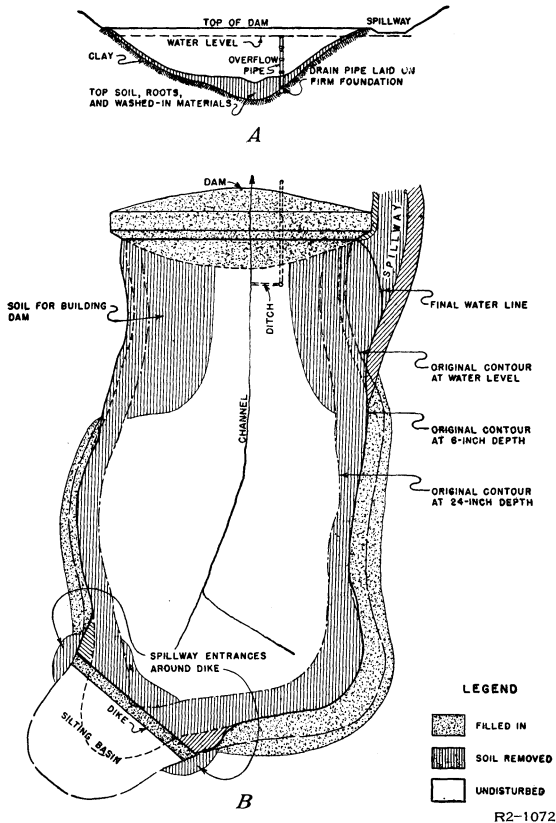


FIGURE 6.—Proper location of a drain pipe and the areas from which soil should be removed for the dam are important when constructing new ponds. *A*, The relative elevations of drain pipe, clay subsoil, porous soil material, water level, spillway, and top of dam. *B*, Areas to be cut and filled, including deepening the edges and diking.

would eventually cut a channel around the dam. If the watershed exceeds 50 acres, an experienced builder of ponds should be consulted.

A wide spillway allows floodwaters to leave the pond as a shallow stream in which the loss of fish is negligible. A fish screen across the spillway is not recommended, even where deeper flows may allow more fish to leave the pond, as screens clog with debris and become a serious hazard to the security of the dam.

If a natural spillway is not available, one can be cut from the hillside at either end of the dam. Digging a flood spillway usually provides a large quantity of soil close to the dam which can be used in



its construction, as was pointed out in the preceding section. Thus, extra-wide spillways actually reduce the cost of dams while increasing safety by the same operation. Care should be taken to leave the floor of the spillway level. If a large spillway cannot be built at one end, smaller ones can be built at each end to accommodate the water that would ordinarily be carried by a large spillway. Erosion of the spillway floor can be prevented by a good sod of grass. Vegetated spillways are greatly protected against damage by an overflow pipe attached to the drain pipe.

A raw open bank must not be left on the side of a spillway as erosion will cause silting of the spillway channel. *Sericea lespedeza* or Bermuda grass is best adapted in the Southeast for holding the soil in place here. Other grasses are adapted to this purpose elsewhere. The slope of the bank should be no steeper than 2 to 1. The bank should be plowed, fertilized, and mulched before being planted.

### DEEPENING THE EDGES

Waters less than 2 feet deep present several problems of maintenance and are of little or no value for fish. Almost every pond can be made more suitable for fish management by deepening the edges to reduce

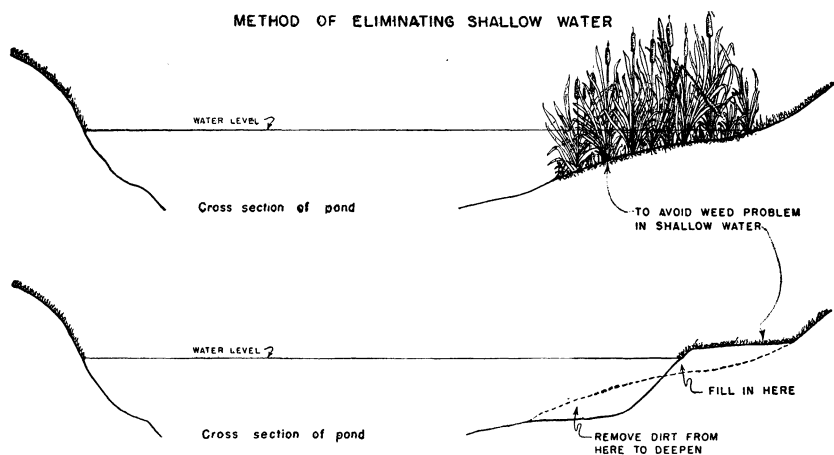


FIGURE 7.—Pond edges should be deepened in order to control emergent water plants and improve fishing.

the areas of shallow water (figs. 6 and 7). Soil from shallow areas near the dam is commonly used in making the fill.

The reasons for deepening the edges are: (1) To make control of waterweeds and mosquitoes easier; (2) to allow bass to reduce the number of small fish more effectively; (3) to store a greater volume of water; (4) to prevent livestock from unnecessarily muddying and destroying spawning beds; and (5) to increase the areas of good fishing from the banks. Waterweeds that grow at the edge can then be reached and easily removed. Where deeper water comes to the edge, mosquito larvae can be more readily eaten by fish and bass are better able to feed on small fish, so that those remaining can reach usable



size more quickly. The entire edge becomes suitable for both bream and bass fishing after deepening.

Deepening is done by filling in the edges where water would be less than 6 inches deep with soil removed from areas which would otherwise be only 6 to 24 inches deep. To accomplish this operation, three contours are staked, one at the natural water level, a second at the 6-inch depth, and the third at the 24-inch depth. The strip between the 6- and 24-inch depths is then plowed, and the soil is scooped from it and moved to the shallower section. This amount of soil will fill the shallow edges and leave a flat bench at least 6 inches above the normal water level. Smooth curving lines should be left for pleasing appearance, rather than making the new edge follow the original 6-inch contour exactly. Deepening to 3 feet instead of 2 is better for ponds fed only by runoff water.

Deepening is needed where the slope is such that a depth of 2 feet would not be reached closer than 8 or 10 feet from the water's edge. If the distance from the shoreline to a depth of 2 feet exceeds 30 or 35 feet, diking may be preferable, as is explained in the following section.

### DIKING THE SHALLOW END

The drainage entrance at the upper end of a pond often slopes very gently. In such cases the area of shallow water (less than 24 inches deep) is considerable. It is easier to dike this area off from the pond than to fill it in with soil. A dike, raised a foot or more above the normal water level, can be located at approximately the 2-foot depth, unless a narrower place is available nearby. (See fig. 6.)

Soil for the dike should be taken from the pond basin thus deepening it more. Runoff water should be allowed to enter the pond around both ends of the dike, where wide spillways should be left for this purpose. The unfilled area above the dike acts as a settling basin for heavy silt. Insecticides may be used to control mosquitoes until the settling basin fills.

Diking, like deepening, is only a refinement in pond construction, but both are worth more than they cost. On sites that are suitable in every way except that they will leave large areas of shallow water, ponds can be constructed successfully only by deepening the edges and diking the shallow end.

### THE FINISHED POND

The finished pond should have the following features:

- A site selected on the basis of good land use.

- Steep sides and a gradual slope up the draw, with areas where the water is less than 2 or 3 feet deep eliminated as far as possible.

- A depth near the dam of from 6 to 8 feet if the water level remains constant or an 8- or 10-foot depth if the water level fluctuates from season to season.

- An adequate water supply. Water from fields, woodland, or pasture is satisfactory if the runoff is virtually silt-free.

- All trees, shrubs, and debris cleared from the pond area and a 15- or 20-foot strip around the edge.

- A permanent drain and overflow pipe so placed that all the water can be drained out if need arises, and large enough to carry at least the normal flow of water without using the flood spillway.

- A well-built dam and an adequate spillway to prevent damage by floodwaters.

- An attractive appearance unmarred by excavations other than the flood-spillways above the water line.

## PROTECTING THE POND WATERSHED

The life and usefulness of a farm pond depend largely on whether lands above the pond are adequately protected by soil conservation measures. The work and expense of building the pond, stocking it with fish, and managing it will be wasted unless the watershed is protected against erosion. When silt fills a pond it becomes useless, and often the only suitable pond site on the farm is ruined. Now that effective erosion-control measures have been developed, silting can be held to a minimum.

Often more than half the rainfall on eroded land runs off and carries a load of soil as it rushes down the slope. As land continues to erode it becomes less fertile and subsequently the fertility of the water entering the pond decreases. A good cover of vegetation protects and holds the soil in place and reduces floods by allowing more of the rain to filter into the soil. When fed from a watershed on which adequate soil conservation practices have been applied, a pond receives water which is essentially silt-free, contains considerable natural fertility, and causes little, if any, flood damage.

Although limited control of silting may lengthen the pond's life somewhat, it will still fail to produce a full crop of fish unless the quantity of light soil particles carried into the pond by runoff water is held to a minimum. This is particularly true where clay soils predominate in the watershed, chiefly because sufficient food for fish is not produced in permanently muddy water.

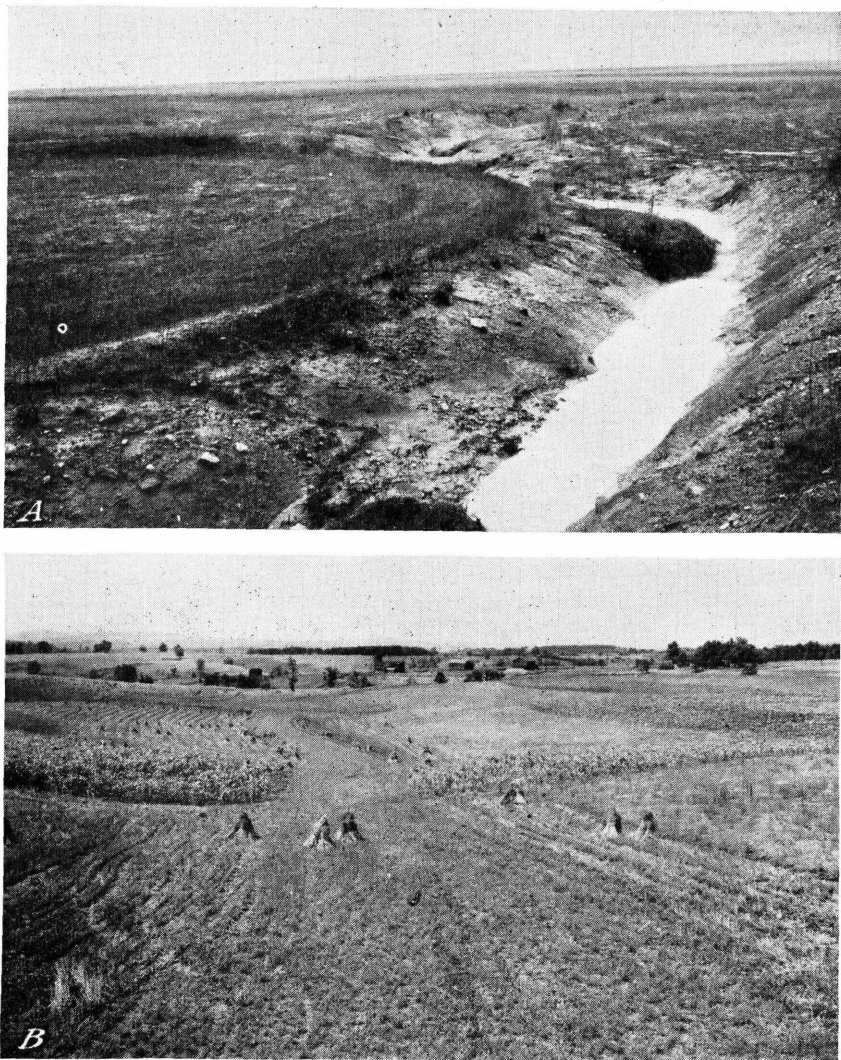
Soil conservation measures prevent the movement of heavy soil particles and greatly reduce the quantities of lighter soil materials that are carried from the land by runoff water. Building a pond should, therefore, be delayed until adequate soil conservation practices have been established. If land in the watershed is poor and eroded, it may require 2 or more years of conservation treatment before a pond can safely be constructed. Diversion of silt-laden waters around a pond is sometimes possible, but erosion and excessive runoff are most effectively controlled at the source.

### WHERE TO CONTROL EROSION

Soil conservation entails using every parcel of land for the purpose to which it is best suited and employing the necessary cultural practices. In order to protect a pond against damage from erosion, soil conservation practices will be needed on the watershed whether the land is used as cropland, hay land, wildlife land, pasture, woodland, roads, or any combination of these.<sup>3</sup>

Sloping croplands need a complete system of crop rotations, cover crops, contour cultivation, terraces, and meadow outlets. These practices reduce sheet erosion, prevent gullies, provide vegetation to strain silt from excess waters as they drain down the slope, and permit more rainfall to filter into the soil (fig. 8).

<sup>3</sup> These practices are discussed in detail in the following publications: TERRACE CONSTRUCTION WITH SMALL EQUIPMENT IN THE SOUTH. U. S. Dept. Agr. [Unnum. Pub.]; PLOWING FOR TERRACE MAINTENANCE IN THE SOUTH. U. S. Dept. Agr. [Unnum. Pub.]; STRIP CROPPING FOR WAR PRODUCTION. U. S. Dept. Agr. Farmers' Bul. 1919; KUDZU FOR EROSION CONTROL IN THE SOUTHEAST. U. S. Dept. Agr. Farmers' Bul. 1940; and PROTECTING FIELD BORDERS. U. S. Dept. Agr. Leaflet 188.



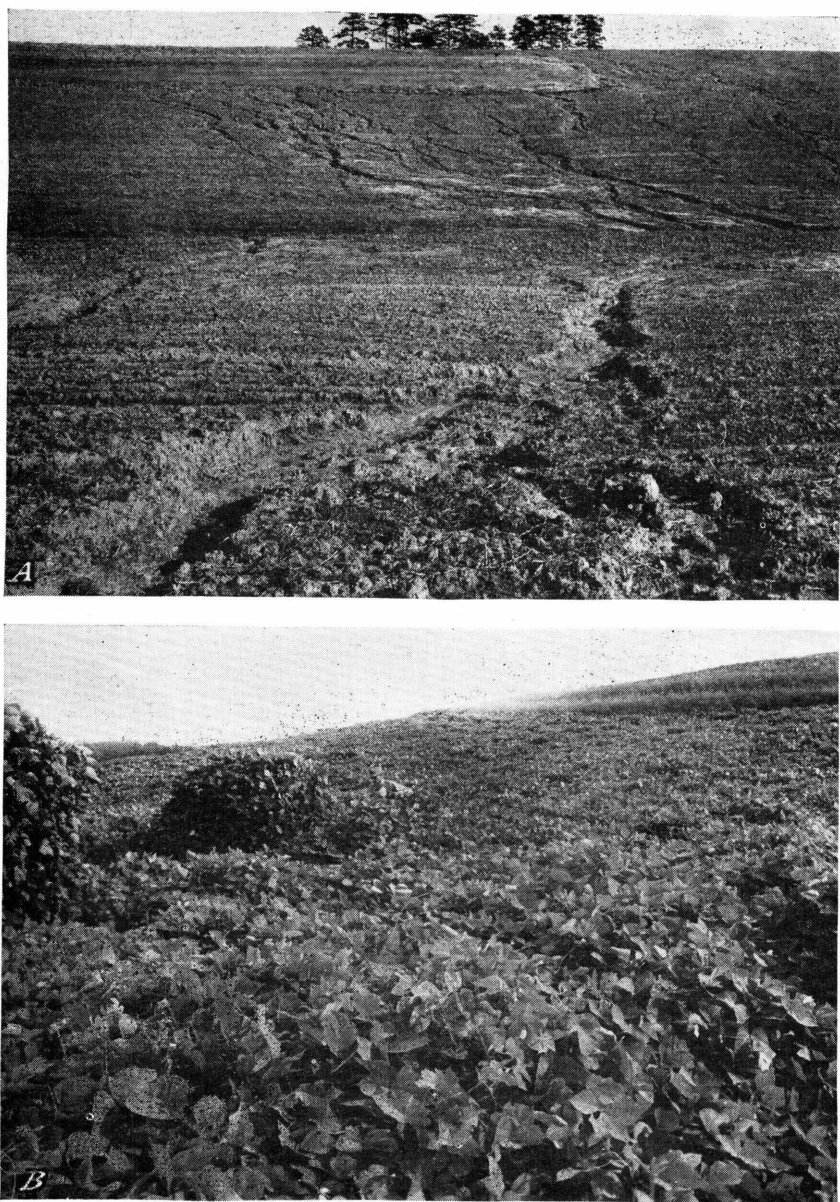
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FIGURE 8.—Soil-conserving practices prevent silting of ponds. *A*, A meadow strip is needed. *B*, A Meadow strip in relation to terraces and crops rotated in contour bands.

The steepest croplands (fig. 9) need perennial hay plants, such as kudzu or sericea, to prevent further deterioration of the land and destruction of ponds below them.

Good pastures keep runoff water practically free of silt. Heavy sods result from proper applications of fertilizer and lime and control of grazing. The right kinds of grasses and legumes for local conditions are important features of soil conservation in pasture management. Kudzu, sericea, and other perennials may be used to hold silt from ponds and to provide supplemental grazing for live-





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FIGURE 9.—A, Critical slopes, when clean-tilled, erode and become unproductive. B, in the South kudzu or sericea lespedeza is a suitable perennial to hold soils in place, increase fertility, and produce excellent hay.

stock on the less productive soils where grasses and annual legumes are not adaptable.

Field and woodland borders, odd corners, rock outcrops, and numerous other small areas that are suitable primarily for the production of wildlife cover and food should be protected by adequate

vegetation. Unless such land is protected by borders of the right kinds of plants, concentrations of water from contour rows usually carry quantities of freshly plowed soil away with every heavy rain. Besides keeping the soil out of ponds, the shrubs, vines, and sericea lespedeza that are recommended for wildlife lands provide desirable foods and shelter for songbirds, bobwhites, and rabbits. Wild fruits for home use can also be harvested from these wildlife lands.

Private and public roads are often large contributors of heavy silt to runoff waters that enter ponds. Road water should be avoided wherever possible, as roadbeds, except those that are hard surfaced, erode rapidly. Individual farmers can help reduce erosion by protecting their farm roads and the sides of roads along their property with vegetative cover. Assistance of soil conservation district, county, and State officials will be needed generally to control erosion along public roads on watersheds above ponds.

Woodland gullies contribute a surprising amount of unwanted silt. These gullies develop when fires, grazing, and concentration of water from other areas remove protective ground cover.

### OLD PONDS AND SMALL LAKES

Some old ponds can be renovated by draining when (1) all fish can be removed, (2) an adequate drain pipe can be installed, (3) the spillway and dam can be made to conform with desirable specifications, (4) existing debris can be removed from the banks and pond area, (5) waterweeds, if present, can be destroyed, and (6) shallow areas deepened, filled in, or diked out. Then the pond can be refilled, stocked, fertilized, and managed as recommended for new ponds. Old ponds should be fertilized a week or two before being stocked because natural fertility is usually low.

Old ponds that cannot be drained can be brought into good production of fish by fertilization and weed control if the pond itself is suitable and has the right balance of bass and bream. An experienced fish culturist will probably be needed to determine the fish and weed problems and to recommend the proper corrective measures.

Lakes can be constructed and managed intensively as a business venture by clubs or groups of farmers. Anyone with sufficient capital to meet the expense of construction and fertilization might sell enough fishing rights to make a profit and thereby remove most of the usable fish as fast as they reach proper size.

The management of large reservoirs presents more problems than small farm fishponds. Erosion, floods, and siltation are serious hazards on large watersheds, and dam and spillway construction require considerable engineering skill. The cost of fertilization and management can be compensated for by intensive use. Farmers, on the other hand, can build and manage small ponds with ordinary farm equipment and materials. Erosion and floods are controlled on small watersheds by good farming measures, the dams and spillways are simple to design and construct, and the proper number of fish is not hard to obtain for stocking. Removing water plants and keeping the pond banks in good condition are not difficult chores. The quantities of fish produced as a result of pond fertilization and management can be profitably and pleasurably used to supplement the farm food supply.